APPARATUS AND METHOD FOR PROTECTING GROUNDING ELECTRODE CONDUCTORS FROM OVERCURRENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. Application Serial Number 09/492,223, filed January 27, 2000.

BACKGROUND--FIELD OF INVENTION

This invention provides a safe means and method for protecting customer's grounding electrode conductors from electric utility ground and open neutral fault currents.

BACKGROUND--DESCRIPTION OF PRIOR ART

Prior art is fully described in the National Electrical Code. The National Electrical Code does not provide an overcurrent protective device for grounding electrode conductors. The Grounding electrode conductors are connected directly from the grounding electrode to the neutral.

Ground faults and/or open neutrals on the electric utility's system, on the line side of the customer's main service, and on customer's electrical equipment have resulted in

an overcurrent protective device for grounding electrode conductors. The grounding electrode conductors are connected directly from the grounding electrode to the neutral.

Ground faults and/or open neutrals on the electric utility's system, on the line side of the customer's main service, and on customer's electrical equipment have resulted in fault currents returning to the system neutral via the (1) earth, (2) grounding electrode, and (3) grounding electrode conductor. Many times these currents are sufficiently large enough to overheat and even melt the grounding electrode conductor and/or neutral conductor. Fires have resulted from the overheating and/or melting of the grounding electrode conductor and/or neutral conductor. Prior art has not prevented these fires and provides no absolute method for positively preventing these fires.

In prior art, the electric utility system's or customer's overcurrent protective devices were relied upon to sense the fault and clear it. However, the settings and sizes of overcurrent devices of the utility's system are set to protect the utility's system equipment only. When setting or selecting these overcurrent devices, no consideration is given to protecting the customers grounding electrode conductor from overcurrents due to utility system ground faults or open neutrals.

The electric utility's neutrals most often have ampacities larger than the ampacity of a No. 6 copper wire, the most common size of the grounding electrode conductors of customers. To provide the required customer load, the electric utility, in most cases cannot size their overcurrent protective devices

small enough to prevent overcurrents on the customer's grounding electrode conductor or neutral conductor.

Likewise, grounding electrode conductors on customer transformers and services are not protected by overcurrent protection on the grounding electrode conductors. Feeder and branch circuit breakers are not sized to prevent overcurrents on grounding electrode conductors at transformers and services.

SUMMARY

In accordance with the present invention an overcurrent device is installed between the neutral and the grounding electrode conductor at the service equipment and at the first overcurrent protection downstream of transformers.

Objects and Advantages

Accordingly besides the objects and advantages of the method of overcurrent protection described in my above patent, several objects and advantages of the present invention are:

(a) to provide a superior method to protect electric utility customer's grounding electrode conductors from overcurrents resulting from electric utility ground faults and open neutrals;

(b) to provide a superior method to protect grounding electrode conductors from overcurrents resulting from ground faults and open neutrals on the customer's service entrance conductors and equipment on the line side of the service equipment;

(c) to prevent fires due to overcurrents on grounding electrode conductors;

(d) to prevent the loss of property and lives from fires originating from overcurrents on grounding electrode conductors;

(e) to provide a method of overcurrent protection which is safe when the overcurrent protection device trips; and

(f) to provide an additional level of safety from ground faults.

Further objects and advantages are to provide a positive method of overcurrent protection of grounding electrode conductors which can be used easily and is inexpensive to manufacture in various ampere ratings to achieve the required protection. Still further objects and advantages will become apparent from a consideration of the following description and drawings.

DRAWING FIGURES

The drawings contain a legend, electrical schematics, table, elevation of a panel, a section of a panel, end views of a panel, top and bottom views of a panel.

Fig. 1 shows a legend of the graphic symbols used in Fig. 2 and Fig. 4, and a legend of the abbreviations used in Fig. 3.

Fig. 2 show an electrical schematic of the method of providing overcurrent protection within a typical customer's service equipment with main circuit breaker.

Fig. 3 shows a table indicating the ampere rating of the overcurrent protective pole for various sizes and types of grounding electrode conductors.

Fig. 4 show an electrical schematic of the means and

method of providing overcurrent protection when two to six circuit breakers are used, as allowed by the National Electrical Code.

Fig. 5 shows an additional embodiment incorporating this invention into a 120/240 volt, 200 ampere, single phase, 42 pole panelboard.

Reference Numerals In Drawings

10 enclosure
12 neutral conductor
14 main thermal-magnetic circuit breaker
16 mechanical linkage/handle tie
18 thermal-magnetic circuit breaker installed in bonding jumper between neutral and equipment ground bus/lug serving as utility fault interrupter and isolator
20 Line No. 1 conductor of single phase/three wire system, or a Phase A conductor of three phase/four wire system
22 Phase C thermal-magnetic circuit breaker pole for three phase/four wire system
24 equipment grounding conductors
26 grounding electrode conductor
28 grounding electrode
30 enclosure bonding conductor
32 equipment ground bus/lug
34 bonding conductor between neutral and utility fault interrupter and isolator

36 bonding conductor between equipment ground bus/lug and utility fault interrupter and isolator

38 insulated neutral bus/lug

40 Line No. 2 conductor of single phase/three wire system, or Phase B conductor of three phase/four wire system

42 Phase C conductor of three phase/four wire system

44 Line No. 1 load conductor/bus of single phase/three wire system, or Phase A load conductor/bus of three phase/four wire system,

46 Line No. 2 load conductor/bus of single phase/three wire system, or Phase B load conductor/bus of three phase/four wire system

48 Phase C load conductor of three phase/four wire system

50 Utility fault interrupter and isolator of main circuit breaker #1

52 Utility fault interrupter and isolator of main circuit breaker #2

54 Utility fault interrupter and isolator of main circuit breaker #3

56 Utility fault interrupter and isolator of main circuit breaker #4

58 Utility fault interrupter and isolator of main circuit breaker #5

60 Utility fault interrupter and isolator of main circuit breaker #6

62 Tap conductor between neutral and utility fault interrupter and isolator of main circuit breaker #1

64 Tap conductor between neutral and utility fault interrupter and isolator of main circuit breaker #2

66 Tap conductor between neutral and utility fault interrupter and isolator of main circuit breaker #3

68 Tap conductor between neutral and utility fault interrupter and isolator of main circuit breaker #4

70 Tap conductor between neutral and utility fault interrupter and isolator of main circuit breaker #5

72 Tap conductor between neutral and utility fault interrupter and isolator of main circuit breaker #6

74 Tap conductor between equipment ground and utility fault interrupter and isolator of main circuit breaker #1

76 Tap conductor between equipment ground and utility fault interrupter and isolator of main circuit breaker #2

78 Tap conductor between equipment ground and utility fault interrupter and isolator of main circuit breaker #3

80 Tap conductor between equipment ground and utility fault interrupter and isolator of main circuit breaker #4

82 Tap conductor between equipment ground and utility fault interrupter and isolator of main circuit breaker #5

84 Tap conductor between equipment ground and utility fault interrupter and isolator of main circuit breaker #6

86 Service entrance in conduit to power panel, 120/120 volts, single phase, three-wire, conforming to Article 230 of the National Electrical Code, but typically three No. 3/0 AWG Type THW copper conductors within a 1 1/2″ rigid metal conduit

87 Locknut

88 Line conductor conforming to Article 230 of the National Electrical Code but typically a No. 3/0 AWG Type THW copper conductor rated 600 volts

92 Neutral conductor conforming to Article 230 of the National Electrical Code but typically a No. 3/0 AWG Type THW copper conductor rated 600 volts

94 Main bonding jumper conforming to Article 250.28 of the National Electrical Code but typically a No. 4 AWG Type THW copper conductor rated 600 volts

96 Neutral bus (bare copper bar) mounts in the panel cabinet on plastic insulator to electrically isolate bar from panel cabinet

98 Insulated branch circuit neutral conductor conforming to Article 310 of the National Electrical Code but typically a No. 12 AWG Type THWN copper condcutor rated 600 volts

100 Insulated branch circuit line conductor conforming to Article 310 of the National Electrical Code but typically a No.12 AWG Type THWN copper conductor rated 600 volts

102 Green insulated equipment ground conductor conforming to Article 310 of the National Electrical Code but typically a No. 12 AWG Type THWN copper conductor rated 600 volts

104 Branch circuit conductors in metal conduit to power branch circuit load, typically 3 No.12 AWG Type THWN copper conductors in 1/2″ metal conduit

106 No. 6 AWG Type THW copper grounding electrode conductor rated 600 volts

108 Grounding electrode conductor in 1/2″ metal conduit

110 Equipment ground copper bar bonded to panel cabinet for termination of equipment ground conductors and main bonding jumper

112 Galvanized steel cabinet, the size of the wiring gutters and gauge of steel will be in accordance with NEMA Standards Publication and U.L. standards No.67 for electrical panelboards. This cabinet will be a NEMA 1, flush or surface mounted enclosure or a NEMA 3R surface mounted enclosure

114 Utility fault interrupter and isolator consisting of a 60 ampere/single pole/120 volt thermal-magnetic molded case circuit breaker with input and output lugs for No.4 AWG copper conductors. This circuit breaker is mounted vertically on plastic insulated barrier. Short circuit rating of circuit breaker is 10,000 RMS symmetrical amperes interrupting capacity.

116 Molded case circuit breaker handle tie mechanically interlocking main circuit breaker handle to utility fault interrupter/isolator handle. Handle tie assures that when either circuit breaker trips, both circuit breakers trip.

118 200 Ampere/2 pole/240 volt main thermal-magnetic molded case circuit breaker with short circuit rating of 10,000 RMS symmetrical amperes interrupting capacity. This main circuit breaker is vertically mounted with incoming lugs for No. 3/0 AWG copper conductors.

120 Branch thermal-magnetic molded case branch circuit breaker, plug-in or bolt-on, rated 120 volt/1 pole or 240 volt/2 pole, Branch circuit breakers range in sizes from 15 amperes to 100 amperes and have short circuit ratings of 10,000 RMS symmetrical amperes interrupting capacity. Branch circuit breakers are mounted horizontally to interior pan and to vertical copper bus bars.

122 Four (4) mounting holes are provided to attach cabinet to vertical surface

124 Six (6) mounting holes are provided to attach front cover to cabinet

126 Cabinet side view (other side is mirror image of this side)

128 Concentric knockout (1″, 1 1/4″, 1 1/2″, 2″) for service entrance conduit

130 Cabinet lip for NEMA 3R cabinets only

132 Cabinet cover plate with openings shown. Cover is made of painted steel. Steel gauge conforms to NEMA Standards Publication and U.L. Standards No.67 for electrical panelboards

134 Main circuit breaker and utility fault interrupter/isolator opening

136 Branch circuit breakers opening

138 Cover front door equipped with three point latch and concealed steel hinges. Door made of painted steel.

140 Flush, brushed stainless steel, cylinder tumbler lock with catches and spring-loaded door pulls

142 Branch circuit breaker directory frame and card with clear plastic covering on inside of door

144 Top and bottom endwall of panel cabinet

146 Service entrance concentric knockout(1″, 1 1/4″, 1 1/2″, 2″) as alternate entrance to serve main circuit breaker

148 Typical concentric knockouts (1/2″,3/4″) for complete flexibility of branch circuit conduit entrance into cabinet

150 Power section plated copper bus bars structure is assembled onto the interior pan in a single, vertical stack, supported continuously by molded polyester glass insulators. Two copper bus bars are part of the structure.

DESCRIPTION-Fig 1-Legend

A legend is given with description of symbols used in Fig 2 and Fig 4 and for abbreviations used in Fig 3. Both symbols and abbreviations are standard symbols and abbreviations used within the electrical industry and by electrical engineers.

Fig 2-Preferred Embodiment

A preferred embodiment of the safe method of overcurrent protection for grounding electrode conductors is illustrated in Fig 2. The schematic indicates an equipment enclosure **10** of service equipment, or of an enclosure of the first circuit breaker(s) downstream of a customer-owned transformer. It is understood that the phrases "service equipment" and "service equipment housing" include but are not limited to load centers, panel boards, switchboards, and breaker boxes. Within the enclosure is an insulated neutral bus/lug **38** connected to an equipment ground bus/lug **32**, via a utility fault interrupter and isolator **18** interlocked with the other poles of the main circuit breaker **14** by a mechanical linkage **16**. The service or transformer neutral **12** is connected directly to the bus/lug **38**. The grounding electrode conductor **26** is not connected to the bus/lug **38**, as is presently done in prior art. The enclosure **10** is bonded to the bus/lug **32**.

Line No. 1 of a 240/120 volt/single phase/three wire system or Phase A of a three phase/four wire system conductor **20** is connected to a thermal-magnetic circuit breaker pole as in prior art. Line No.2 of a 240/120 volt/single phase/three wire system or Phase B of a three phase/four wire system conductor **40** is also connected to a thermal-magnetic circuit breaker pole, as in prior art. It is understood that the phrase "overcurrent protector" includes but is not limited to circuit breakers and fuses. Phase C of a three phase/four wire system conductor **42** is connected to a thermal-magnetic circuit breaker pole where the system is three phase/four wire. Conductor **42,** Phase C load conductor **48,** and Phase C circuit breaker pole **22** are only required where the system is three phase/four wire. Line No. 1 of a 240/120 volt/single phase/three wire system or Phase A of a three phase/four wire system conductor **44** is connected to the bus of a panelboard, switchboard, or to other electrical equipment downstream. Line No. 2 of a 240/120 volt/single phase/three wire system or Phase B of a three phase/four wire system conductor **46** is connected to the bus of a panelboard, switchboard, or to other electrical equipment downstream. Conductor **48** is connected to the bus of a panelboard, switchboard, or to other electrical equipment downstream.

Fig 3-Table

Fig 3 is a table giving the ampere rating of the utility fault interrupter/isolator for protection for the grounding electrode conductors. All acceptable conductors, of prior art as listed in Table 250-66 of the National Electrical Code are listed, along with the ampere rating of the utility

fault interrupter/isolator for the given conductor. Ampere ratings are based on the ampacity of the conductor as given in Table 310-16 of the National Electrical Code. The ampere ratings and ampacities were selected using prior art applied to other conductors, but not applied to grounding electrode conductors. Conductors used for grounding electrode conductors have the same ampacities as the conductors listed in Table 310-16 of the National Electrical Code, and are in fact the same conductors. The ampere ratings selected are the same as or lower than the recognized ampacities of the conductors, assuring that the grounding electrode conductor does not overheat and ignite any adjacent combustible materials.

Fig 4-Additional Embodiment A

Fig 4 is an additional embodiment indicating the connections of additional utility fault interrupters/isolators where more than one circuit breaker serve as service disconnects as allowed by the National Electrical Code Section 230-71.

The Neutral bus/lug **38** is connected to the equipment ground bus/lug **32** via line side conductors **62, 64, 66, 68, 70,** and **72** connected to utility fault interrupters/isolators **50, 52, 54, 56, 58,** and **60** of the circuit breakers. Utility fault interrupters/isolators **50, 52, 54, 56, 58,** and **60** are used in only the quantities necessary for the additional main circuit breakers used, up to a maximum of six as allowed by the National Electrical Code Section 230-71. Each utility fault interrupter/isolator is mechanically linked to the line or

phase circuit breaker poles of the line or phase overcurrent trips of the circuit breaker. For example, if the system was a 240/120 volt/single phase/three wire system with six service disconnects or six main circuit breakers, each of the six main circuit breakers would be three-pole circuit breakers. One pole for the overcurrent protection of the grounding electrode conductor and two poles for overcurrent protection of the line conductors. All three poles would be mechanically linked so that all three poles trip in unison.

Conductors **74, 76, 78, 80, 82,** and **84** are tap conductors on the load side of the utility fault interrupters/isolators to connect these poles to the equipment ground bus/lug **32**. A single grounding electrode conductor **26** connects the bus/lug **32** to a grounding electrode **28**. Tap and grounding electrode conductors are sized as required by Article 250 of the National Electrical Code, as is current practice.

If the service equipment has only one main circuit breaker and service disconnect, only Reference Numericals **38, 62, 50, 74, 32, 26,** and **28** are used. If the service equipment has two main circuit breakers serving as service disconnects, only Reference Numericals **38, 62, 64, 50, 52, 74, 76, 32, 26,** and **28** apply. If the service equipment utilizes three main circuit breakers as service disconnects, then only Reference Numericals **38, 62, 64, 66, 50, 52, 54, 74, 76, 78, 32, 26,** and **28** apply. If the service equipment consists of four main circuit breakers as service disconnects, then all Reference Numericals apply except Reference Numericals **70, 72, 58, 60, 82,** and **84**. If the service equipment has five main circuit breakers as service disconnects, then all Reference Numericals

apply except Reference Numericals **72**, **60**, and **84**. If the service equipment has six circuit breakers serving as service disconnects, then all Reference Numericals are applicable.

The ampere rating of each utility fault interrupter/isolator is sized for the ampacity of the conductor **26** divided by the number of service disconnect circuit breakers or the ampacity of the tap conductors, whichever is smaller.

If the multiple main circuit breakers are within separate enclosures, as allowed by the National Electrical Code, then each enclosure would be bonded to the equipment ground bus/lug.

Taps on grounding electrode conductors are used in prior art as allowed by Article 250-64(d) of the National Electrical Code.

Fig 4-Additional Embodiment B

Fig 5 is an additional embodiment indicating how this invention is incorporated into a 200 ampere, 240/120 volt, single phase panelboard.

Advantages

From the description above, a number of advantages of my overcurrent protection method for grounding electrode conductors become evident:

(a) Positive overcurrent protection of the grounding electrode will prevent numerous fires that occur each year due to electric utility ground faults and other ground faults that result in zero sequence current returning to the system neutral

via the grounding electrode conductor. Prior art did not provide any positive protection from electric utility ground faults and open neutrals.

(b) The method of connecting the grounding electrode conductor and circuit breaker, panelboard, or switchboard enclosures to the equipment ground bus/lug directly assures that the enclosure will be at ground potential at all times, even during ground faults and after the circuit breaker(s) have tripped. This feature allows individuals to safely handle and touch the enclosure and circuit breaker after the breaker has tripped to reset the circuit breaker.

(c) The mechanical linkage from the added grounded electrode conductor pole of the circuit breaker to the line or phase poles assures trippage of all poles during ground faults. This de-energizes all electrical equipment for safety reasons when the connection between the neutral and grounding electrode conductor is opened by the added grounding electrode conductor pole of the circuit breaker.

(d) Interrupting and ampere ratings of circuit breaker poles are adequate and readily available within the marketplace.

(e) Since the ampere rating of the circuit breaker pole on the grounding electrode conductor will be smaller than the line or phase circuit breaker pole ampere ratings, an additional level of safety from ground faults within the facility will be achieved.

Operation--Fig 2

The manner of using the utility fault

interrupter/isolator for overcurrent protection of the grounding electrode conductor is identical to the manner in which multiple poles of circuit breakers are used to provide overcurrent protection for line and phase conductors. Adequate interrupting ratings are readily available. The mechanical linkage **16** is the same linkage used today on multiple pole circuit breakers, usually in the form of handle ties.

When an overcurrent condition is sensed by the utility fault interrupter/isolator **18** for a single circuit breaker, the multiple pole circuit breaker **14** trips, opens the connection between the grounding electrode conductor **26** and the neutral bus/lug **38**, and opens all line or phase conductors. This interrupts the zero sequence current path to the system neutral and prevents an overcurrent situation on the grounding electrode conductor. This also de-energizes all electrical service to the facility.

The mechanical linkage **16** assures that all poles of the circuit breaker open, even if only one pole senses an overcurrent. This is required to de-energize the facility if the grounding electrode conductor to neutral path is opened for any reason and to comply with Article 230-90(b) of the National Electrical Code.

The bus/lug **38** is insulated from the enclosure **10** to eliminate a zero sequence current path from the grounding electrode conductor, to the enclosure, and to the neutral. An uninsulated neutral bus/lug would prevent the invention from working properly.

The conductor **26** is not connected directly to the bus/lug **38**, but is connected via the utility fault

interrupter/isolator **18**, so that the zero sequence current path between grounding electrode **28** and the neutral can be opened. Interrupting ratings of the utility fault interrupter/isolator would be selected based upon the maximum ground fault current available at the installation as is presently done for phase or line overcurrent devices.

The enclosure **10** is bonded to the equipment ground bus/lug **32** with a bonding conductor **30** to keep the enclosure at ground potential at all times, including after the tripping of the circuit breaker **14**, when someone will go to the enclosure to reset the circuit breaker. This prevents that person from being shocked or electrocuted. Even if the ground fault still exists, the enclosure and circuit breaker are safe to touch.

Equipment grounding conductors **24** are connected at all times to the bus/lug **32**, to assure that at all times the grounded equipment within the facility is grounded.

Operation--Fig 4

The manner of using the additional utility fault interrupters/isolators on multiple line or phase circuit breakers to protect from overcurrents on the grounding electrode conductor is identical to that described above in Fig 2, except that: (1) multiple utility fault interrupters/isolators are used, (2) tap conductors are used to connect the individual utility fault interrupters/isolators between the neutral bus/lug **38** and the equipment ground bus/lug **32**, and (3) the ampere rating is sized for the ampacity of grounding electrode

conductor divided by the number of main circuit breakers or the ampacity of the tap conductors, whichever is smaller.

When an overcurrent is sensed on any of the utility fault interrupters/isolators, the circuit breaker trips, opening all poles of the circuit breaker whose utility fault interrupter/isolator sensed the overcurrent. The other circuit breakers remain closed until their individual utility fault interrupter/isolator senses an overcurrent. Once all utility fault interrupters/isolators have sensed an overcurrent and tripped, the fault current path from neutral to grounding electrode is opened and all the electricity to the facility is turned off.

When individual utility fault interrupters/isolators trip, the portion of the fault current flowing through these tripped poles begins to flow in the non-tripped utility fault interrupters/isolators and will cause the other utility fault interrupters/isolators to trip, if an overcurrent still exists. Individual mechanical linkages trip all poles of each main circuit breaker.

Conclusion, Ramifications, and Scope

Accordingly, the reader will see that the method and apparatus for interrupting electric utility ground and open neutral fault currents of this invention can easily be manufactured using readily available equipment. This invention will add a level of electrical safety not achieved by prior art and will prevent fires and deaths due to overcurrents on grounding electrode conductors.

The scope of this invention should be determined by

the appended claims and their legal equivalents, rather than by the examples given.